

What we claimed:

1. A aircraft simulator for training the pilots under wake vortex danger conditions consisting of:

a module (1) for control of the simulator modes capable of choosing a training scenario and controlling operation of the simulator modules,

a training scenarios database module (2)

a module (3) for commutation of the simulator modules,

a module (4) for imitation of outside visual situation, visual part of the air space and ground surface in real time,

a module (6) for simulation of the pilot workplace,

a module (5) for simulation of the aviation instrument panel with indication of the of aircraft engine modes,

a module (8) for simulation of the controls for the aircraft units and systems,

the module (7) for simulation of the ambient parameters,

a module (9) for simulation of the wake vortex situation capable of determining the vortex generator wake vortex path as the set of the vorticity region centers and intensity on the basis of information from the training scenarios database module (2) and of information from the module (7) for simulation of the ambient parameters,

a module (10) for simulation of wake vortex perturbation effects on the aircraft capable of evaluation of the aircraft additional forces and moments induced by the vortex generator wake vortices on the basis of information on the wake vortex path and intensity received from the module (9) for simulation of the wake vortex situation, of information on the aircraft parameters received from the training scenarios database module (2), and of information on the aircraft position, flight velocity, angular rates, and geometrical characteristics received from the module (11) for simulation of the aircraft dynamics,

a module (11) for simulation of the aircraft dynamics capable of forming signals imitating the aircraft forces and moments according to the training scenario, as well as additional forces and moments induced by the vortex generator wake vortices, and transmitting the signals to the module (6) for simulation of the pilot workplace, module (5) for simulation of the aviation instrument panel, and module (4) for imitation of outside visual situation on the basis of information from the module (10) for simulation of wake vortex perturbation effects on the aircraft, from the training scenarios database

module (2), and from the module (8) for simulation of the controls for the aircraft units and systems,

a system for evaluation of the pilot actions capable of estimating correctness of the pilot actions against the flight situation hazardous for the aircraft on the basis of information received from the module (4) for imitation of outside visual situation and the module (5) for simulation of the instrument panel.

2. The simulator as claimed in claim 1 wherein the module (6) for simulation of the pilot workplace is made with a possibility of changing its attitude and is equipped with the device for dynamic imitation of flight.

3. The simulator as claimed in any of claims 1–2 wherein the module (9) for simulation of the vortex situation includes:

a unit (13) for simulation of vortex generator dynamics including the vortex generator tracker capable of receiving information on the vortex generator position, motion parameters, geometrical and weight characteristics from the scenarios database module (2) and the memory unit capable of storing information on the vortex generator position and motion parameters;

a unit (14) for simulation of wake vortices including the wake vortex tracker capable of determining the vortex generator wake vortex path in the form of the set of the vorticity region center trajectories and intensity on the basis of information from the module (7) for simulation of the ambient parameters and module (13) for simulation of vortex generator dynamics and also capable of saving the information on the coordinates of points of the vortex generator wake vortex path in the form of the set of the vorticity region center trajectories and intensity;

and the module (10) for simulation of wake vortex perturbation effects on the aircraft should contains:

a unit (15) for the aircraft schematization capable of calculating the set of the aircraft geometrical characteristics necessary for calculation of the aircraft additional aerodynamic forces and moments induced by the vortex generator wake vortices on the basis of information on the aircraft type and configuration the training scenario database module (2), and

a unit (16) for determination of the above mentioned forces and moments on the basis of the information on the coordinates of points of the vortex generator wake vortex

path in the form of the set of the vorticity region center trajectories and intensity saved by the unit (14) for simulation of wake vortices and of information on the aircraft position, flight velocity, angular rates, and geometrical characteristics received from the module (11) for simulation of the aircraft dynamics.

4. The simulator as claimed in any of claims 1-3 wherein it additionally comprises the module for simulation of noise, optical and dynamic effects.

5. The simulator as claimed in any of claims 1-4 wherein it is adjusted for training in pilotage under the conditions when the pilot receives information on the forecasted possibility of the aircraft encounter with the vortex generator wake vortex danger area and additionally comprises:

- a module (17) of parameters of the vortex perturbation danger area including:

- a unit (20) for evaluation of perturbation hazard capable of estimating the perturbation hazard level at the given point according to the chosen hazard criteria for the aircraft additional aerodynamic forces and moments induced by the vortex perturbations on the basis of information received from unit (16) for determination of the forces and moments, which belongs to the module (10) for simulation of wake vortex perturbation effects on the aircraft;

- a unit (21) for determination of danger points where the additional forces and moments induced by the vortex perturbations are dangerous; the unit is capable of determining the coordinates of points belonging to the danger area according the hazard criteria based on information received from the unit (20) for evaluation of perturbation hazard;

- a unit (22) for determination of the vortex perturbation danger area capable of calculating the danger area geometrical characteristics on the basis of information received from the unit (21) for determination of danger points and transmitting the corresponding information;

- and the warning module (18) including:

- a unit (23) for selection of the delay time capable of calculating the time period within which the aircraft has at least a possibility of a flight evasive maneuver providing evasion of the aircraft from the generator wake danger area after the signal warning against the possibility of wake encounter has been received;

a unit (24) for simulation of the control plane capable of calculating the delay distance, which equals to the distance covered by the aircraft during the delay time, modeling the control plane situated in front of the aircraft perpendicular to its flight direction at the delay distance, and determining the forecasted time necessary for the aircraft to gain the control plane in the inertial frame;

a forecasting unit (25) capable of determining the generator wake path in the form of the set of the generator vorticity region centers with respect to the inertial frame and of the intensity of the generator wake vortices at the forecasted time on the basis of information from the unit for simulation of wake vortices in the module for simulation of vortex situation;

a unit (26) for calculation of the intersection points capable of determining the coordinates of the intersection points of the generator wake vortex trajectory and the control plane at the forecasted time of the aircraft flight through it;

a areas and regions forming unit (27) capable of forming around the intersection point of the wake vortex path and the control plane of the wake vortex danger area in the form of the set of the generator vorticity danger areas, where the entering aircraft may have the flight parameters exceeding the admissible limits; forming in the control plane of the area of the aircraft forecasted positions at the forecasted time of the aircraft intersection with the control plane with due regard to the flight regulations; forming around the region of the aircraft forecasted positions of the alert area; the information on the entrance of the wake danger areas into the alert area will be provided to the user;

a transformation unit (28) capable of calculating the coordinates of the area of the aircraft forecasted positions, of the alert area and of the wake vortex danger area in the aircraft frame;

first intersection conditional test unit (29) capable of calculating the distance from the alert area to the wake vortex danger area and marking its nulling;

second intersection conditional test unit (30) capable of calculating the distance from the area of the aircraft forecasted positions to the wake vortex danger area and marking its nulling;

an indication unit (31) containing at least one indication device capable of indicating the nulling of the distance from the alert area to the generator wake vortex danger area;

a emergency indication unit (32) containing at least one indication device capable of indicating the nulling of the distance from the area of the aircraft forecasted positions to the danger area of the generator wake vortices.

6. The simulator as claimed in claim 5 wherein it comprises the module of visualization including a visualization device capable of forming the image at least of the area of the aircraft forecasted positions and wake vortex danger areas on the basis of information received from the warning module.

7. The simulator as claimed in any of claims 5-6 wherein the indication and emergency indication devices are chosen from the group containing devices of visual, audio and tactile indication.

8. The simulator as claimed in any of claims 5-7 wherein the unit (23) for selection of the delay time can perform the current correction of the delay time in a manual, semiautomatic or automatic mode.

9. The simulator as claimed in any of claims 5-8 wherein the areas and regions forming unit (27) is developed with a possibility of performing the current correction of the coordinates of the alert area and area of the aircraft forecasted positions in a manual, semiautomatic or automatic mode.

10. The simulator as claimed in any of claims 5-9 wherein the unit (22) for determination of the danger area parameters could be designed with a possibility of approximating the boundaries of the vortex generator wake vortex danger area.

11. The simulator under any of items 5-10 differing in that the aircraft admissible roll moment induced by wake vortices is chosen as the hazard criterion.

12. The simulator under any of items 5-10 differing in that the admissible value of the aircraft roll angle is chosen as the hazard criterion.

13. The simulator under any of items 1–12 differing in that the training scenarios are chosen from the group including takeoff and landing at a ground airdrome, takeoff and landing at the aircraft carrier, individual and formation flight, and flight refueling.

14. The simulator under any of items 1–13 differing in that it is implemented in the software of the simulator modules of the operation of the simulator's modules.

15. The simulator under any of items 1–14 differing in that the module (7) for simulation of the danger area parameters contains the database of characteristics of wake vortex danger areas for different types of vortex generators.

16. The simulator under any of items 1–15 differing in that the system (12) for estimation of the pilot actions contains the memory device for saving information on the coordinates of the control plane, area of the aircraft forecasted positions and wake vortex danger areas of vortex generators located in the aircraft vicinity at least within the time of emergency indication of the nulling event for the distance from the area of the aircraft forecasted positions to the danger area of the vortex generator wake vortices.